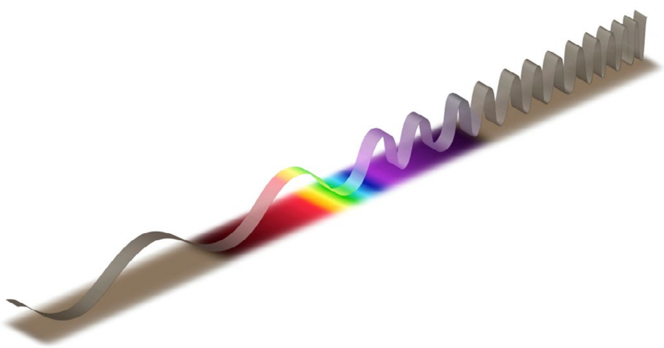
Cambridge Assessment International Education

# Example Responses – Paper 4

## Cambridge O Level
## Physics 5054

For examination from 2023



Cambridge Pathway

# Contents

# Introduction

The main aim of this booklet is to exemplify standards for those teaching Cambridge O Level Physics 5054.

This booklet contains responses to all questions from June 2023 Paper 42, which have been written by a Cambridge examiner. Responses are accompanied by a brief commentary highlighting common errors and misconceptions where they are relevant.

The question papers and mark schemes are available to download from the School Support Hub

**5054 June 2023 Question Paper 42**

**5054 June 2023 Mark Scheme 42**

Past exam resources and other teaching and learning resources are available from the School Support Hub

# Question 1

**1** A student measures the capacity of a drinks cup by three different methods.

The capacity of a cup is the maximum volume of liquid that it can hold.

**(a) method 1**

The student measures:

- the height *h* of the cup
- the diameter *D* of the top of the cup
- the diameter *d* of the bottom of the cup.

Fig. 1.1 shows a full-size diagram of the cup.

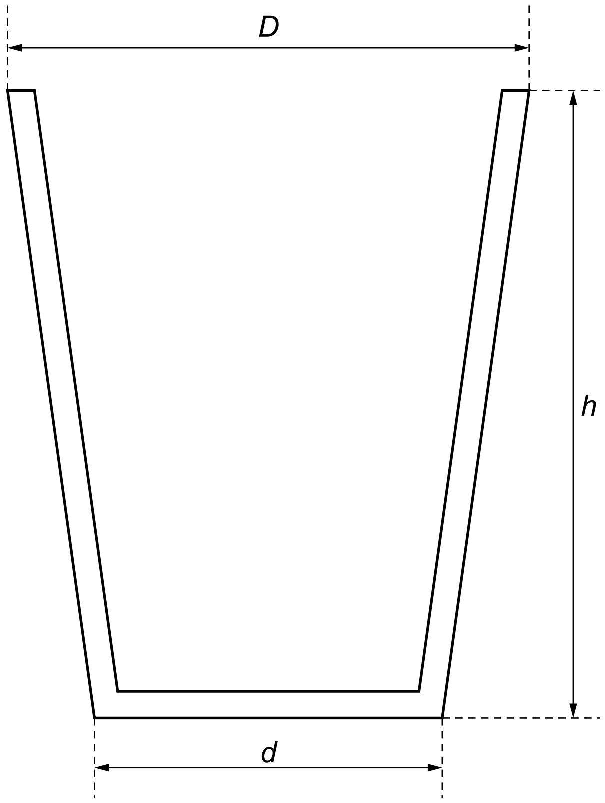



**Fig. 1.1**

**(i)** Measure the height *h*, the diameter *D* and the diameter *d* of the cup in the diagram.

*h* = ........8.3........ cm

*D* = ........6.9........ cm

*d* = ........4.6........ cm

[2]

## Examiner comment

To be awarded the first mark, candidates needed to write *h*, *D* and *d* to the nearest millimetre (0.1 cm). They were awarded the second mark for the correct values.

**(ii)** Calculate the average diameter $d_A$ of the cup using your readings from **(a)(i)** and the equation:

$$d_A = \frac{(D + d)}{2}$$

$$d_A = \frac{(6.9 + 4.6)}{2}$$

5.75

$d_A$ = ..........5.75.......... cm [1]

**(iii)** Calculate a value for the capacity $V_1$ of the cup using the equation:

$$V_1 = \frac{\pi d_A^2 h}{4}$$

$$V_1 = \frac{[\pi \times (5.75)^2 \times 8.3]}{4}$$

$V_1$ = ..........215.6.......... $cm^3$ [1]

## Examiner comment

- The calculation should have been correct and with correct rounding of numbers. Allowance was made for some variation in the final response due to the various approximations of π, or the value built into different calculators. For this paper, when there was no specific demand for an answer to be given to a number of significant figures, then it is advisable to write numbers to several significant figures and then round off the final answer, usually to 2 or 3 significant figures.
- Candidates needed to recognise whether the answers to their calculations were realistic by developing the skill of making rough estimates of quantities. The cups used should have had volumes of about 200 - 250 $cm^3$ and an average circumference in the region of 18 to 25 cm. Calculated values which were very different from these values (for example, twice as much or one or more powers of ten different) should suggest to the candidate that they should check their measurements and calculations, and also check whether they used the correct units These skills would be easily applied to other subjects such as chemistry and mathematics in addition to physics.

**(b) method 2**

The student uses a length of string and a metre rule to determine the average circumference *C* of the cup.

The student:

- wraps some of the string 5 times around the cup
- measures the length $l$ of string used.

$$l = 87.9\,\text{cm}$$

**(i)** Calculate the average circumference *C* of the cup.

$$C = \frac{87.9}{5}$$

*C* = ..........17.58.......... cm [1]

## Examiner comment

The string was wrapped around the cup 5 times, so C = 87.9 ÷ 5.

**(ii)** Use your values of $h$ from **(a)(i)** and $C$ from **(b)(i)** to calculate a value for the capacity $V_2$ of the cup using the equation:

$$V_2 = \frac{C^2 h}{4\pi}$$

$$V_2 = \frac{[(17.58)^2 \times 8.3]}{4\pi} = 204$$

$V_2$ = ..........204.......................................... $cm^3$ [1]

## Examiner comment

Allowance was made for some variation in the final response due to the various approximations of $\pi$ or its value built into different calculators. Answers should have been given to 3 or more significant figures.

**(c) method 3**

The student:

- fills a measuring cylinder with water, up to the 220 $cm^3$ mark
- pours water from the measuring cylinder into the cup until the cup is full
- records the new reading $R$ on the measuring cylinder.

Fig. 1.2 shows the new reading $R$.

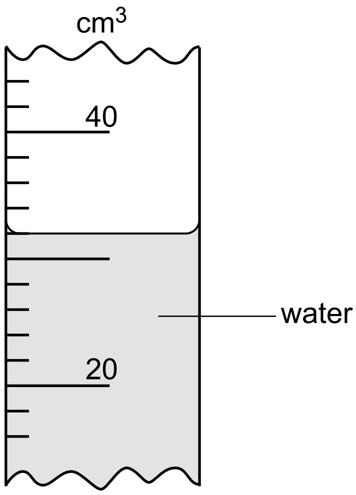



**Fig. 1.2**

**(i)** Write down the new reading $R$.

$R$ = ..........32.......................................... $cm^3$ [1]

## Examiner comment

32 or 32.0 were accepted for $R$.

**(ii)** Determine the volume of water $V_3$ in the cup.

Show your working.

$V_3 = 220 - 32 = 188$

$V_3$ = ..........188.......... $cm^3$ [1]

## Examiner comment

The initial volume was 220 $cm^3$.

**(d)** All three methods of determining the capacity of the drinks cup give values which are approximate.

State **one** reason why the volume calculated in **method 2** and **one** reason why the volume calculated in **method 3** are **not** accurate.

**method 2** the string may not have been wrapped tightly enough around the cup

**method 3** some water may have been left in the cup or the measuring cylinder

[2]

## Examiner comment

- Candidates only needed to give one reason, and not a list of reasons, for each method.
- Alternative responses for method 2 alternative included 'the string is slightly stretchy', 'it has thickness', 'it may have slipped as it was wrapped round the cup', or 'there may have been some overlap of the loops'.
- Alternative responses for method 3 included that the cup may have been slightly underfilled or overfilled as there was no line marking the level where the cup was deemed to be full. Water could have been spilled while being transferred from one vessel to the other. There could have been water left in the cup. There could have been a parallax error if volume readings were not taken at right angles to the reading on the scale.
- 'Parallax error' alone would not have been enough to gain the mark.

# Question 2

**2** A student investigates the effective resistance of different combinations of resistors and lamps in circuits.

The student sets up the circuit shown in Fig. 2.1.

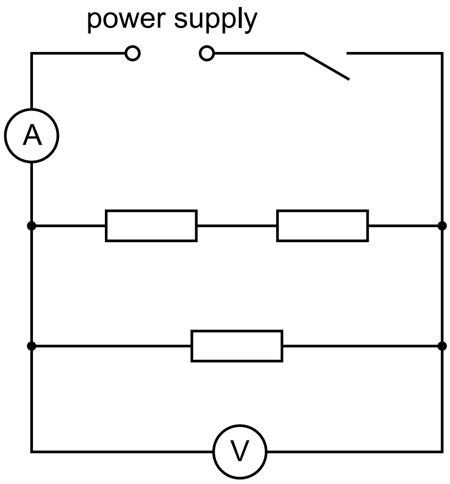



**Fig. 2.1**

**(a)** The student:

- closes the switch
- measures the potential difference $V_1$ across the resistors and the current $I_1$ in the circuit
- opens the switch.

The readings on the voltmeter and ammeter are shown in Fig. 2.2 and Fig. 2.3.

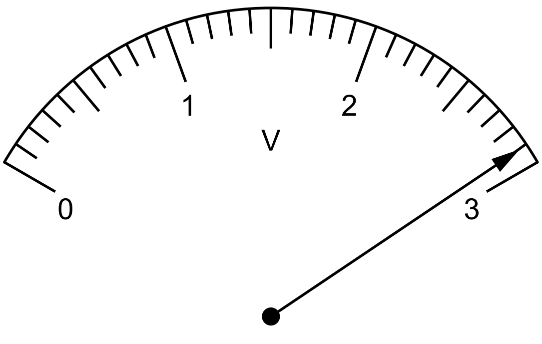



**Fig. 2.2**

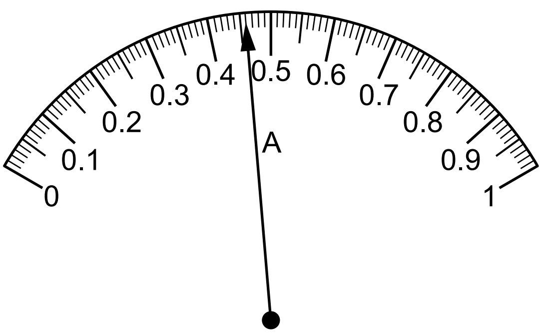



**Fig. 2.3**

**(i)** Record the potential difference $V_1$ and the current $I_1$ shown in Fig. 2.2 and Fig. 2.3.

$V_1$ = ......2.9...... V

$I_1$ = ......0.46...... A
[2]

**(ii)** Calculate the effective resistance $R_1$ of the combination of resistors using the equation:

$$R_1 = \frac{V_1}{I_1}$$

$$R_1 = \frac{2.9}{0.46} = 6.30$$

$R_1$ = ......6.30...... Ω [1]

**(iii)** Suggest why the switch is opened after the readings of potential difference and current have been taken.

to prevent the resistors from overheating

.............................................................................................................. [1]

## Examiner comment

'Resistor' could have been replaced with 'circuit'. 'Heating' or 'overheating' were acceptable terms, but 'burning' or 'short circuit' were incorrect.

**(b)** The student:

- rearranges the circuit so that the resistors are connected as shown in Fig. 2.4
- closes the switch
- measures the potential difference $V_2$ and the current $I_2$
- opens the switch.

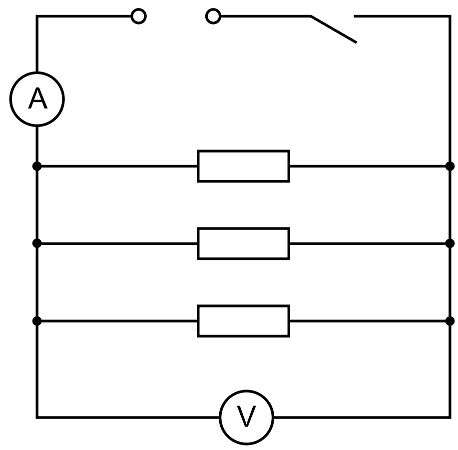



**Fig. 2.4**

The new readings are:

$$V_2 = 2.8\,\text{V}$$

$$I_2 = 0.88\,\text{A}$$

Calculate the effective resistance $R_2$ of the combination of resistors using the equation:

$$R_2 = \frac{V_2}{I_2}$$

Record your answer on the answer line.

Write down the value of $2R_2$

$$R_2 = \frac{2.8}{0.88} = 3.18181$$

$$2R_2 = 6.3636 = 6.36\ \Omega$$

$R_2$ = ..........3.18.......... Ω

$2R_2$ = ..........6.36.......... Ω

[1]

## Examiner comment

Candidates needed to round the values correctly.

**(c)** If the resistors are identical, theory suggests that $R_1 = 2R_2$.

Two quantities can be considered to be equal within the limits of experimental accuracy if their values are within 10% of each other.

State whether the results indicate that the resistors are identical. Support your statement with a calculation.

calculation

$$\% \text{ difference} = \frac{100 \times (6.36 - 6.30)}{6.36} = 0.9\%$$

statement yes, the resistors can be considered identical because the difference between them is only 0.9 % which is less than 10 % [2]

## Examiner comment

It was essential for candidates to show an appropriate calculation, with a comparison of the percentage difference between the two values and with the 10 % difference between the two values.

An alternative valid calculation would be:

'the larger value, $R_2$ is 6.36 Ohms

10 % of 6.36 is 0.636

upper limit of experimental accuracy is 6.36 + 0.636 = 6.996

lower limit of experimental accuracy is 6.36 – 0.636 = 5.724

the smaller value, $R_1$ is 6.30 and lies between these limits:

$5.724 < 6.30 < 6.36 < 6.996$

Statement: the two resistors can be considered to be identical because 6.30 is within 10 % of 6.36'

**(d)** The student repeats the experiments in **(a)** and **(b)** but replaces the resistors with lamps. He obtains the following results:

The effective resistance $R_3$ of the combination of lamps connected as in Fig. 2.1 is 5.2 Ω.

The effective resistance $R_4$ of the combination of lamps connected as in Fig. 2.4 is 3.4 Ω.

The teacher explains that the resistance of the lamp filaments changes due to a heating effect and therefore $R_3$ is not equal to $2R_4$.

Suggest **one** observation that the student makes while doing the experiment that supports the teacher's explanation.

the lamps get hot and glow and they are brighter in the circuit where they were all in parallel [1]

## Examiner comment

All that was required here was a simple statement of what the candidate saw: the lamps were much brighter in the fourth circuit. No explanation was required, but the lamps were brighter because they were hotter.

**(e)** The student extends the investigation using a different combination of the three lamps to the two combinations already used in **(a)** and **(b)**.

Complete the circuit diagram in Fig. 2.5 to show a third way of connecting three lamps between X and Y.

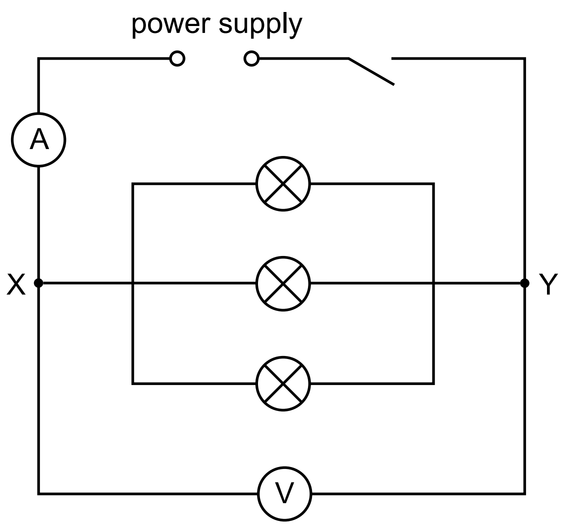



**Fig. 2.5**

[2]

## Examiner comment

Candidates needed to use the correct symbol for a lamp. The correct symbol is a circle with a diagonal cross within it, touching the edges of the circle and there should be two horizontal connections to the rest of the circuit, one at each side of the circle. Three lamps should have been drawn in parallel in a correct circuit that would work. (Alternatively two lamps could have been placed in parallel with each other and then connected in series with the third lamp).

# Question 3

**3** A student investigates the image formed by a converging lens.

The student arranges the apparatus as shown in Fig. 3.1.

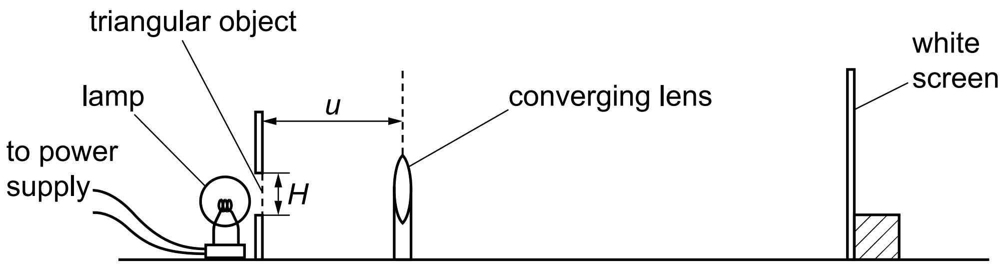



**Fig. 3.1** (not to scale)

The illuminated triangular object is shown full size in Fig. 3.2.

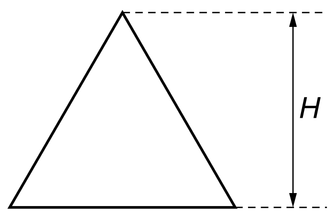



**Fig. 3.2**

**(a)** Measure and record the height *H* of the triangular object.

*H* = ..........................2.6.......................... cm [1]

## Examiner comment

*H* was the vertical distance from the middle of the base to the apex. Some candidates incorrectly wrote down the length of one side of the triangle.

**(b)** The student:

- switches on the lamp and places the lens a distance $u$ = 20.0 cm from the triangular object
- adjusts the position of the screen until a sharp, focussed image of the triangular object is formed on the screen.

The image is shown full-size in Fig. 3.3.

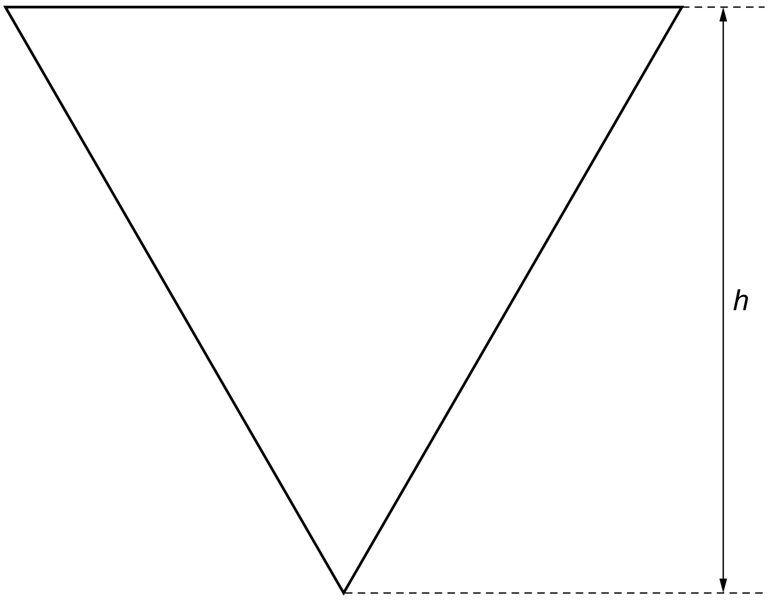



**Fig. 3.3**

**(i)** Measure the height $h$ of the image on the screen shown in Fig. 3.3 on page 11.

$h$ = ..........7.8 cm.......... [1]

## Examiner comment

*h* was the vertical height of the image. No unit was given, so candidates could have written it in centimetres or millimetres and they could have given the unit, but this was not essential.

**(ii)** Calculate the value of $\frac{1}{h}$.

Give your answer to 2 significant figures.

$\frac{1}{h}$ = ..........0.13 $cm^{-1}$.......... [1]

## Examiner comment

$\frac{1}{h}$ was the reciprocal of the vertical height of the image. No unit was given, so candidates could have written their answer in 1 / centimetres, $cm^{-1}$, 1 / millimetres or $mm^{-1}$. They could have given the unit, but this was not essential.

Add your values for $h$ and $\frac{1}{h}$ to Table 3.1.

**(c)** The student repeats **(b)** for different values of $u$.

He records all his readings in Table 3.1.

**Table 3.1**

| $u$/cm | $h$ ……/ cm…… | $\frac{1}{h}$ ……/ cm$^{-1}$…… |
|---|---|---|
| 20.0 | 7.8 | 0.13 |
| 25.0 | 3.9 | 0.26 |
| 30.0 | 2.6 | 0.38 |
| 40.0 | 1.6 | 0.63 |
| 50.0 | 1.1 | 0.91 |

**(i)** Complete the headers by adding appropriate units. [1]

**(ii)** Calculate the remaining values of $\frac{1}{h}$ and add them to Table 3.1. [1]

## Examiner comment

The units were an essential part of the headers to the table in order for the first mark to be awarded for the headings to each column of the table. The second mark was awarded for $u$ values being spread across the range of 20 to 50 cm and $h$ decreasing as $u$ increased. The third mark was awarded for values of $h$ and $\frac{1}{h}$ having been recorded to consistent and appropriate levels of precision down each column of results.

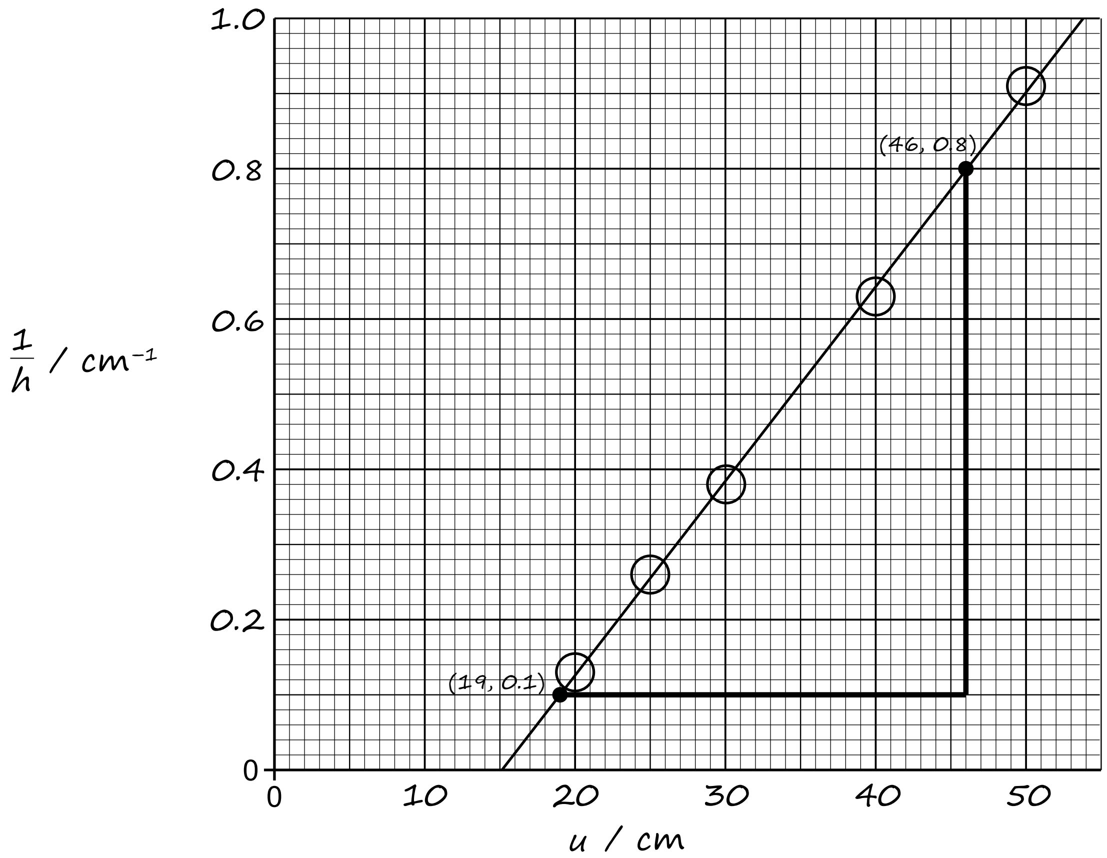
**(d)** The screen is a square sheet of white card of side 10 cm. Look at the data in Table 3.1 and suggest why the student does not use values of $u$ which are less than 20.0 cm.

the image would have been too large to fit onto the screen

…………………………………………………………………… [1]

**(e)** On the grid provided, plot a graph of $\frac{1}{h}$ on the *y*-axis against *u* on the *x*-axis.

Start both axes from the origin (0, 0). Draw the straight line of best fit.




[4]

**(f)** **(i)** Calculate the gradient *m* of your line. Show all working and indicate on the graph the values you use.

two points marked on the line:

points chosen: (19.0, 0.10) and (46.0, 0.80)

$$m = \frac{0.80 - 0.10}{46 - 19} = \frac{0.70}{27} = 0.025926$$

*m* = 0.026 [2]

## Examiner comment

Candidates should not have used points from the table. They needed to clearly indicate the selected points, and the best way to do this was to draw a 'gradient triangle' as shown on the graph.

**(ii)** Calculate the focal length *f* of the lens. Use your value of *H* from **(a)** and the equation:

$$f = \frac{1}{mH}$$

$$f = \frac{1}{0.026 \times 2.6}$$

*f* = 14.8 cm [1]

## Examiner comment

A common error was for candidates to substitute *h* and not *H*.

**(g)** When measuring the height of the image on the screen, the student's hand and the ruler obstruct the light from the object and prevent it from reaching the screen.

Suggest **one** improvement to the apparatus used by the student to overcome this problem.

make pencil marks on the screen at the top and bottom of the image and then measure the vertical distance between them (this is the height of the image) [1]

## Examiner comment

Candidates could also have stated that a calibrated screen could have been used, or that a piece of graph paper or a scale could have been fixed to the screen, or a translucent screen could have been used and the measurements made on the back of it.

# Question 4

**4** A student investigates the time taken for ice cubes to melt when they are placed in a beaker of hot water.

Plan an experiment to investigate how the thickness of the cardboard insulation around a beaker affects the time taken for the ice cubes in the beaker to melt.

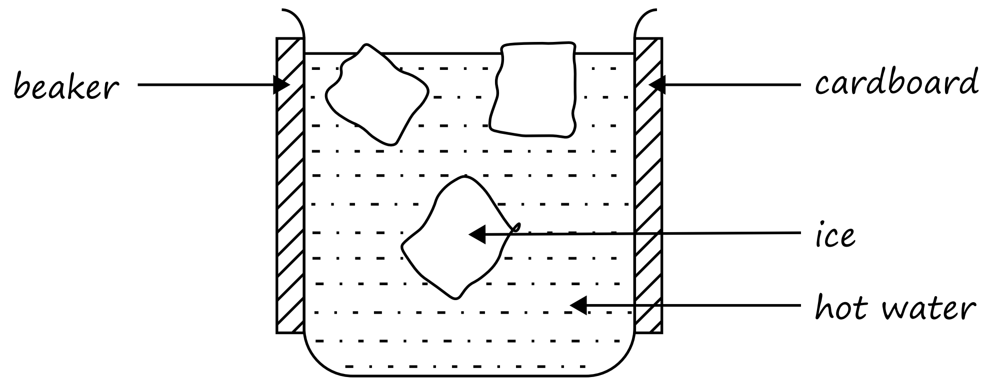
You are **not** required to do this experiment.

The following apparatus is available:

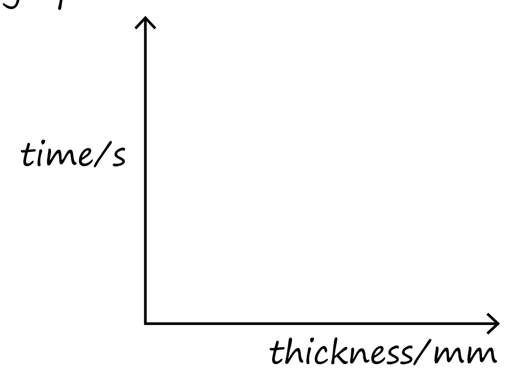
250 cm$^3$ beaker
supply of hot water
supply of ice cubes
thermometer
stopwatch
supply of 2 mm thick cardboard sheets.

In your plan you should:

- explain briefly how to carry out the investigation
- state the key variables to keep constant
- draw a table with column headings to show how to display the readings
- explain how to use your readings to reach a conclusion.




graph:




Wrap the beaker with one sheet of 2 mm thick cardboard and secure it in place. Pour a measured amount of hot water into the beaker and measure the temperature of the water. When the water has cooled to the chosen starting temperature add the ice cubes and at the same time start the stopwatch. Stop the stopwatch as soon as all the ice has melted. Record the time taken for the ice to melt and the thickness of the cardboard. Repeat the experiment using an extra layer of cardboard each time until 5 layers of cardboard have been added. Use the same starting temperature and volume of water, the same mass of ice cubes and the same beaker used each time. The room temperature should also be constant.

Record the results in a table:

| Number of cardboard layers | Thickness / mm | Time / s |
|---|---|---|
| 1 | 2 | |
| 2 | 4 | |
| 3 | 6 | |
| 4 | 8 | |
| 5 | 10 | |

Compare the times taken for the ice to melt for different thicknesses of cardboard and plot a graph of time (y-axis) against thickness (x-axis) to see if there is a relationship between the time and the thickness of the cardboard.

## Examiner comment

- Marking points 3 and 6 appeared to be the less frequently marks awarded.
- Marking point 1 was awarded for text or a good, correctly labelled diagram describing hot water and ice inside a beaker that has been wrapped around the outside with cardboard.
- A common misconception was to draw or describe how the cardboard was placed inside the beaker.
- Marking point 2 was awarded if candidates showed that the timing started when the ice was put into the hot water and stopped exactly when the last piece of ice had melted.
- Many candidates incorrectly thought that the temperature had to be measured at regular intervals or that the timing stopped when the temperature began to rise, but these timings would have led to inaccurate results. The thermometer was only used to check the initial temperature(s).
- Marking point 3 was awarded if there was evidence that a set of data for a total of 5 or more different thicknesses of cardboard were to be collected. This was in line with guidance on plotting graphs that a minimum of 5 points should be plotted. Some candidates described measuring the time for melting with or without cardboard, but this did not answer the question 'how the thickness of the cardboard insulation around a beaker affects the time taken.'
- To be awarded marking point 4, candidates needed to specifically mention at least one appropriate quantity that was going to be kept constant for each run of the experiment. The question did not specify how many variables to list so more than one could and should have been listed. The most important variables have been listed in this example response.

- To be awarded marking point 5, the minimum for the table needed to be in two columns, one for the number of sheets of cardboard (or thickness of cardboard, with a correct unit) and one for the time (with a correct unit). A common misconception by candidates was to replace ‘thickness’ by ‘amount of insulation’ or just ‘insulation’ but these two terms are not the name of the physical quantity being measured. The best responses were those which had columns for thickness (mm) and time (s) so that there was suitable data to plot a line graph. A line graph would usually be preferable to a bar chart.
- For marking point 6, a line graph was the best method of showing any relationship between the time and the thickness of cardboard, whereas a bar graph would be plotted for the relationship between the time and the number of sheets. If candidates didn’t mention a graph then they needed to include a sentence instead indicating that the times for different thicknesses would be compared to see if the time for the ice to melt was affected by the thickness of the cardboard.
- Candidates should not use predictions as the conclusion. In this experiment, an expected prediction would be for the melting time to increase as the thickness of the cardboard increased. Suitable wording to change it from a prediction to an acceptable response would be, ‘compare the results in the table to see if the melting time increased as the thickness increased’. It may have been of help to the candidate to imagine that it was not known whether the thickness affected the melting time and how they could make a decision on whether there was a link between the two quantities if this was the first ever time it had been investigated.

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